hylio

AgroDrone Spray System

AG-110

Operations Manual V2.4

Contents

Spec Sheet

Flight Parameters	
Total Weight (without batteries)	23.0 lb
Max Recommended Takeoff Weight	55.0 lb
Max Thrust	134.8 lb
Max Operating Speed	22 mph
Max Flight Speed	40 mph
Propulsion System	
Motor KV	100 rpm/V
Foldable Propeller	30x9.0 in
Configuration	Quadcopter
Operating Voltage	12s
Battery	1 x 16000 mAh 12S (44.4V) LiPo Battery
	9.3 lb/battery
Aircraft Frame	
Wheelbase	51 in
Material	Carbon Fiber, Aluminum, Plastic
Dimensions	46x46x24 in (arms unfolded)
	23x23x20 in (arms folded)
Spray System	
Standard Payload	21lb, 2.5 gallon
Configuration	1 Pump, 1 Tank, 1 Flowmeter, 4 nozzles on 6ft boom
Nozzle	Nozzle body compatible with any Teejet spray tip
Pump Pressure	Diaphragm Pump, 65 PSI
Flow Rate (no nozzle max)	0.1 – 1.1 Gal/min
Flow Rate (with recommended nozzle TT11001)	0.5 Gal/min
Spray Width	10-20 feet
Flight Control	
Flight Modes	Fully autonomous (no RC), position hold manual (with RC), Fully manual GPS denied (with RC)
Operating Frequencies	902 – 928 MHz, 2.4 GHz
Ground Station Control Software	Hylio Agrosol
Max Transmission Range	~1 mile (5+ unobstructed)

Accessory Hardware

Refer to maintenance manual for UAS hardware information

GPS Tracker

- GPS Tracker unit is used for field survey and marking
- Tracker is NOT required to generate flags and obstacles in AgroSol
- Tracker is NOT required to create missions in AgroSol
- Tracker connects to ground station computer using a standard micro-USB cable
- Tracker requires a 2-minute boot-up time to acquire satellites

Batteries/Charger

Dual charger unit shown

- Each charger comes with:
  - Two 12-pin balance cables
  - One AC power cord
- One 12s (50V) battery power UAS
- Be careful not to get the battery balance cables wet or damage the battery structure, this will increase risk of fire

16000Mah 12s Battery shown

- Press button to display current charge level
- Number of triangles lit up represent battery health, more triangles mean battery total capacity is reduced

How to Charge Batteries

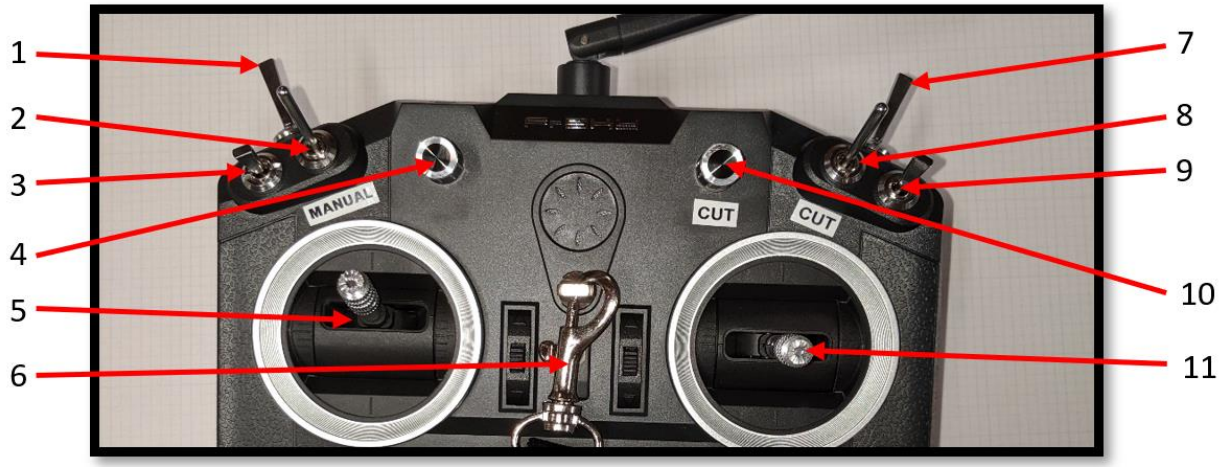
Steps

1. Plug Charger AC power cord into 120V outlet
2. Plug AS150-U and 12-pin balance cables from battery into charger
3. Press on/off button to turn on charger
4. Turn knob to trickle, standard, or fast to select desired charge speed
5. Wait 10 seconds OR press and hold charge button to begin charge
6. Press and hold button again to stop charge.
7. Press and hold storage button to start storage charge

Tips

1. Try not to charge hot batteries. Wait for them to cool before charging
2. DO NOT discharge batteries below 10%. Avoid discharging below 15%
3. Storage charge batteries if they will not be used for over a week
4. Trickle charge batteries to improve longevity and performance

Remote Controller



*All switches are shown in the default position. The default position of the throttle stick is pulled down to the bottom

1	Back Switch 1	Manual Pump Switch: Toggle Pump On/Off
2	Inside Switch 1	Flight Mode Switch: Position Hold (Top position) RTL (Middle position) Land (bottom position)
3	Outside Switch 1	Not Used
4	Knob 1	Not Used
5	Stick 1	Vertical Velocity: Move stick up and down control altitude Control Yaw: Move stick left and right to yaw CCW and CW
6	Power Button	Hold power button 3s to turn RC on or off
7	Back Switch 2	Not Used
8	Inside Switch 2	Emergency Kill Switch Part 1: pull switch down to instantly kill motor power. Must be used in conjunction with Knob 2 to kill motors.
9	Outside Switch 2	Not Used
10	Knob 2	Emergency Kill Switch Part 2: turn knob all the way clockwise to instantly kill motor power. Must be used in conjunction with Inside Switch 2 to kill motors.
11	Stick 2	Horizontal Velocity Left-Right: Move left-right to control UAS left-right position Horizontal Velocity Forward-Back: Move forward-back to control UAS forward-back position

Safety Notice:

1. ALWAYS make sure throttle stick (Stick 1) is centered before switching drone into position hold mode during an active mission.

2. ALWAYS be prepared to use the kill switch in the case of an extreme emergency. If the RC is connected, this switch will power down the motors no matter the situation or aircraft status.

Ground Control Station

- Ground Station Includes:
  - Laptop/Tablet (not included with all kits)
  - RFD900 Radio Telemetry Unit and antenna (configured in AgroSol)
  - FTDI Cable (connect RFD900 to Laptop/Tablet)
  - Manual flight RC
- Ground station computer requirements:
  - Windows 10
  - I3 Processor or better
  - 8GB Ram or better
- Manual flight RC NOT required for standard mission operation

System Capabilities

Features Overview

The AG-110 contains an array of features to both enhance safety and assure its ability to effectively conduct the mission. Among these features are:

Ground Control Software System - Hylio Inc. and all AG-110 owners use a UAS ground control software system known as Hylio AgroSol. Hylio Inc. developed AgroSol for the express purpose of controlling Hylio Inc. agricultural drones. AgroSol has been used for ground station control of all recorded flight hours on the AG-110.

Return-To-Launch (RTL) - The operator has access to an RTL command which they can use to instantly stop the UAS and return it to the set landing point at a predetermined, safe altitude

Land - In the event that the primary and all backup land points have been compromised, the UAS can be autonomously landed in any other safe location. This can be completed using the ground control software without requiring manual RC control.

Emergency Pause - The operator has systems that can be used to instantly stop the UA during the mission, where the drone will pause and hover in place, awaiting further commands. It can then be manually moved to a new location, and forced to land at the alternate safe landing location, or return to launch for landing.

Geofencing - The UAS's flight controller is given GPS coordinates of a boundary that it cannot leave, keeping the UAS from leaving the pre-determined and defined operations area. When enabled, the UAS can "hit" the perimeter, but not fly past or through it. Manual or automatic inputs commanding the UAS to break the geofence are ignored. In the event the geofence is broken, the UAS will automatically enter RTL mode and return home to land.

Beacon - In the extremely unlikely event of a system malfunction that causes a crash, a beacon attached to the UAS will help the PIC and ground crew quickly locate it, ensuring a quick response to secure the equipment and surrounding area.

Redundant GPS - All UAS are equipped with redundant GPS units. Should the primary GPS unit experience a failure, a second GPS unit will automatically takeover as a failsafe to ensure accurate positioning and navigation is maintained. During regular operation, the GPS signals are blended to improve position accuracy. The system offers full redundancy of GPS (2), IMU (3), and Compass (3). If one or multiple units fail, the controller will switch in real-time between the redundant compass, IMU, and GPS.

Telemetry - Should a telemetry link to the base station be lost, the UAS has all mission parameters stored onboard, and can safely continue to execute a mission. The UAS will automatically return to land with or without telemetry link when the tank or batteries are low. The base station computer will alert the PIC when telemetry communication is lost, who may opt to allow the UAS to continue its mission if it is safe to do so, or interrupt the mission and bring the UAS back under RC control.

RC control - All missions occur with pre-programmed commands providing instructions to the UAS. At all times the PIC has an RC remote located near the ground control station, with the ability to override the current mission. The AG-110 offers an optional safety feature where in the case that the RC connection is lost, the autopilot software will immediately end the mission and return the UAS home launch location. In this case, the UAS ascends to an altitude set by the PIC in advance of the mission and determined to be safe given the surrounding terrain. The UAS then returns in a straight line to the launch location.

Emergency Kill Switch - An emergency "Kill Switch" allows the operator to instantly stop motors in the event of an emergency. This kill switch is available through both the ground control computer telemetry link and the RC.

Full Black Box Recording of All Flights - Flight data shows time stamped information of all operator control input, GPS statuses and outputs, vibrations, battery voltage, accessory voltages, IMU outputs, compass readings and all other sensor and flight information. All flight information is automatically saved internally on the UAS. Any operator or system caused issues can be easily identified with this information. Hylio's ground control software offers analysis of this log information to help predict potential future problems. As a supplement to routine maintenance, these logs are analyzed daily to help protect the user from unforeseen issues. This process can be completed locally on AgroSol without the need for internet access. If an operator feels there may be an issue, logs from the last flight can be analyzed using AgroSol in minutes without leaving the field.

Obstacle Detection and Avoidance - The AG-110 uses two radars facing forward and back to detect obstacles around the drone. In the event that an obstacle is detected, the UA will immediately pause the mission and wait for command. To ensure operational safety, this feature is optional and can be turned on/off in AgroSol.

Safety parameters - Max altitude, distance from home, horizontal speed and vertical speed defaults are set by Hylio Inc., and the customer can set these as well based on location and operating restrictions. The AG-110 uses multiple sensor types to ensure maximum altitude is respected in the event of primary altimeter sensor failure.

Aviation Lighting - All AG-110 come with mounted navigation lights in a standard configuration to indicate orientation and health. Hylio offers optional Long-range visible, high intensity LED strobes. Back 2 are white. Front right is green. Front left is red.

Intelligent Assisted Launch and Landing - Aircraft uses GPS and IMU data to determine when the craft is fully on the ground, meaning the craft will not shut rotors off until firmly on the ground. Aircraft also uses IMU data to safely and smoothly handle "In Ground Effect" caused by the rotor downwash, which lessens stress and accident likelihood for operator.

Flight Stall Prevention - The flight controller prevents accidental 'throttle zero' motor stall while in the air. In an emergency, the operator can switch instantly to 'manual' mode to activate rotor kill, providing complete system override by the pilot during an in-flight emergency. This override is also available through the ground control station computer over the telemetry link.

5-second auto-lock rotors - Automatically locks rotor from accidental turning after initial power connected and again five seconds after rotors stop.

Change of Flight Parameters - Ability to change certain parameters in real-time (during flight).

Flight Controller Modifications - Ability to program, calibrate, debug, and modify flight controller information without power to rotors: allows safe physical interaction with UAS while performing maintenance and servicing.

GPS Signals - For UAS operations where GPS signal is necessary to safely operate the aircraft, the PIC must immediately recover/land the UAS upon loss of GPS signal. Without a GPS signal, the drone is unable to maintain its location within the fenced spray location. Therefore, the drone immediately enters land mode, unless the PIC takes over manual control.

Altitude Sensing Redundancies - The AG-110 uses 3 different sensors to determine altitude. Radar, barometer, and GPS. The radar is the primary source of altitude. If the radar fails, the drone will automatically RTL using barometer altitudes. If the radar fails, the Geofence will also be maintained using the barometer altitude to ensure the UAS does not exit the geofenced area.

Lost Link - If the PIC loses command or control link for a designated length of time, the aircraft will follow a predetermined route to finish the mission, reestablish link, or immediately return to land if the first two options are not possible. The UAS will automatically return when for low battery, or fluid in the tank, even when the link is lost. To ensure operational safety, this feature is optional and can be turned on/off in AgroSol. All safety features including automatic obstacle detection and avoidance remain in effect in the event of a lost link.

Operational Analysis - The AG110 flight controller firmware automatically logs flight hours on the UAS. These flight hours are tracked and displayed in AgroSol. This automatic flight hour tracking is used to ensure strict adherence to maintenance procedures.

Lost Link Failsafe

Activation Criteria

- The lost link failsafe can be turned on and off in AgroSol.
- When it is turned on, the failsafe will activate when there is a complete loss of connection with the ground control station via the telemetry link for a sustained 10 seconds.

Activation Actions

- Upon Lost Link Failsafe activation, the drone immediately enters RTL mode.
- When the drone enters RTL mode, Land mode, Pause mode, or any other failsafe mode: The pump immediately turns off.
- Immediately upon activation, obstacle avoidance is automatically enabled.
- In RTL mode, the drone first climbs to the set cruise altitude, then proceeds directly to the designated safe landing point and lands.
- When connection is regained with the ground station, the drone will not return to continue the mission. The drone will continue on to RTL and land, unless another command is sent.

Recommended Conditions to Enable/Disable

- Lost link failsafe is ALWAYS recommended to enable if the mission is possible to complete with this failsafe enabled.
- Only disable this failsafe if it can be confirmed that the airspace will be clear throughout the flight. Use a visual observer who is carrying the RC if possible.

Fly-Away Prevention

History

The Fly-Away has been a common problem with commercial UAS brands since their early adoption, particularly DJI. In 20,000+ flights across all Hylio UAS from 2015-2020, no Hylio Inc. Drone has ever experienced a Fly-Away event.

Prevention Measures

Hylio UAS are assembled in the USA of the highest quality components from across the world, and go through an intensive QA process before delivery. All Hylio missions are geo-fenced and saved internally on the UAS, to ensure there is no possibility of a Fly-Away in the event of a communications hardware failure. Hylio AgroSol reads back each mission after it is uploaded to confirm there was no mission data corruption during transmission. These steps ensure the UAS only follow missions as intended by the operator.

Fly-Away Procedures

Given the prevention measures above, the only cause for a Fly-Away would be a GPS system failure of both the primary and secondary GPS. In the event of such a failure, the drone immediately enters land mode. Given that the drone is no longer capable determining its location to maintain the integrity of its geofence, it was determined that an emergency land in the current location would be the safest course of action.

Obstacle Avoidance

Activation Criteria

- The front and rear radars constantly search for obstacles around the drone. The lidar tracks and monitors objects within 30 meters of the UAS. Once a tracked obstacle comes within 10 meters of the UAS, avoidance action is initiated. 10 Meters is a default value that can be changed.

Activation Actions

- If the drone sees an obstacle beyond the setting value (default 10 meters) then it will slow down so that it will be able to stop before coming within 10 meters of the obstacle. It will continue following the mission but will slow enough to ensure it can stop in time to maintain the minimum obstacle distance.
- When the drone flies up to the 10 meter obstacle distance, it will stop in place. If in an auto mission the drone will pause and wait for further command. If it is in manual flight mode the drone will not allow you to fly closer than the OA range set distance. This distance can be set in the drone settings on the planning tab.

Conditions to Enable/Disable

- Obstacle Avoidance is ALWAYS recommended to enable if the mission is possible to complete with this failsafe enabled.
- It may increase operational safety to disable obstacle avoidance only when a crop being treated gives many false obstacle positives. This can sometimes happen with very uneven crop heights. This can greatly reduce efficiency and increase risk by causing the drone to frequently deviate from its predetermined flight plan. First, attempt to increase the spray altitude to reduce false positives. If false positives continue, you may disable avoidance.
- Only disable this failsafe if it can be confirmed that the airspace will be clear throughout the flight. Use a visual observer who is carrying the RC if possible.
- The PIC must understand that without enabling obstacle avoidance, the drone may collide with any obstacle in the mission area. The mission area must be THOROUGHLY surveyed for potential obstacles before proceeding with avoidance disabled.

System Operation

Spray Mission Workflow

Step 1: Survey

1. Travel to mission area before scheduled application.
2. Locate all fields to be treated.
3. Survey fields for dangerous topography, obstacles, nearby residences, and any other criteria that may disqualify a field for UAS application.
4. Use GPS Tracker to safely mark flags and obstacles on all application areas. (This step not required if field is previously marked or an imported shapefile is deemed safe).
5. Confirm that all obstacles within the application area are safely marked.
6. Determine chemical and rate for application on these properties.

Step 2: Pre-Mission Preparation

1. Draw mission shape files in AgroSol. Follow all mission planning safety guidelines.
2. Calculate chemical ratio that will be used for the application.
3. Select safe mission speed and altitudes for this area. Follow all safety guidelines.
4. Charge all flight batteries.
5. Confirm all required operational equipment is accounted for and in good condition.

Step 3: Spray Missions

1. Travel to spray area. Unload drone in a safe location as close as possible to application area. This will reduce ferry time and improve efficiency.
2. Notify property owner that UAS operations will commence.
3. Begin spray procedures. Follow all preflight checks. Follow all UAS and chemical safety guidelines.
4. After completion, notify property owner. Rinse spray system and pack up. Follow safety guidelines for equipment transportation.

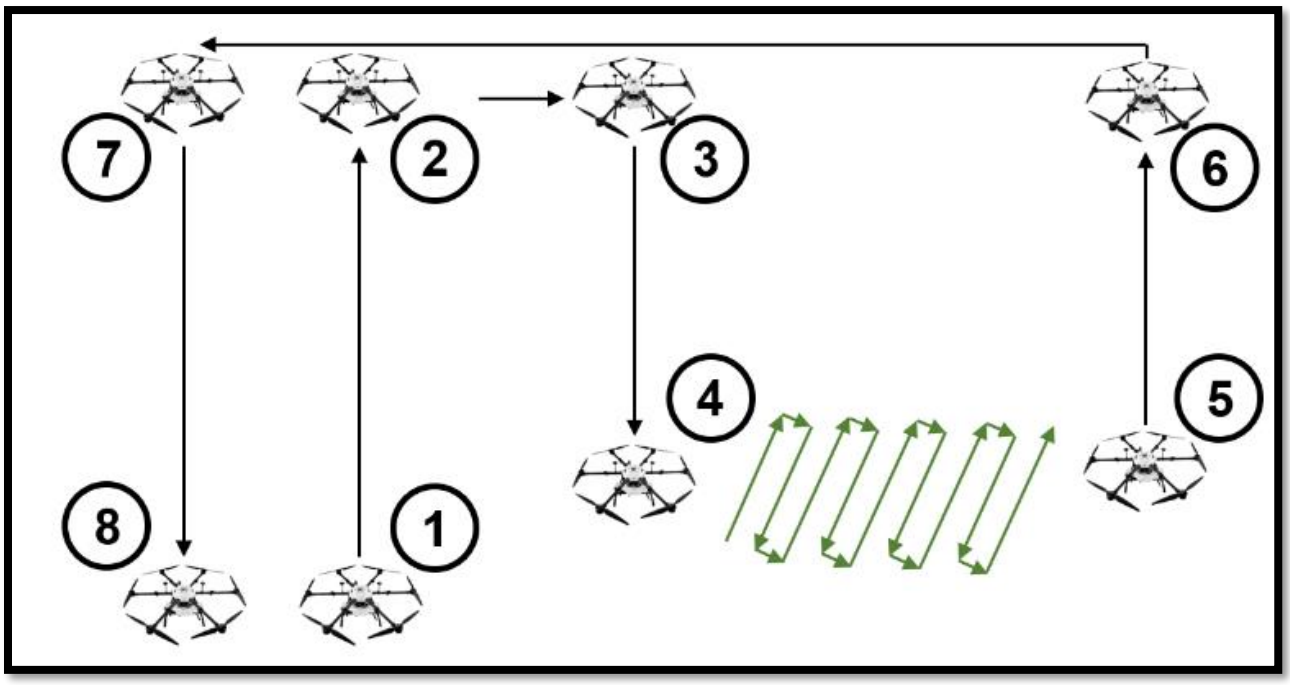
Step 4: Daily Maintenance

1. Follow Daily Maintenance Checklist.
2. Upload flight logs whenever possible.
3. Ensure equipment is stored safely. Follow storage safety guidelines.

Standard Flight Pattern

AgroDrone spray missions follow a standard flight pattern, as outlined by the 8 steps below.

1. Arm Motors. Take Off. Climb to **Cruise Altitude**
2. Reach Cruise Altitude. Fly to Mission Spray Area at **Flight Speed**
3. Reach Mission Spray Area. Descend to **Spray Altitude**
4. Reach Spray Altitude. Follow Mission Path & Spray Field
5. Area Completed, Battery Depleted, Tank Empty, or Mission Paused by Operator: Stop, Climb to Cruise Altitude
6. Reach Cruise Altitude. Fly to Land Point.
7. Reach Land Point. Descend to Land.
8. Land. Motors Disarm.



Cruise Altitude (ft): UAS Altitude during flight to area, RTL (return to land), and Pause mode
Spray Altitude (ft): UAS Altitude
Flight Speed (mph): UAS Speed during the entire mission

AgroDrone: Pre-Flight Checklist

PIC _____ VO _____

Date _____ Drone _____

STEP 1:	**DRONE**	
	1: Arm	All 4 arm elbow connectors screwed on tight
	2: Propeller	Remove bands/foam holders. Propellers tight and straight, inspect all 4 for cracks and chips
	3: Spray	Spray bars tightly secured; All tubes connected; No leaks; Nozzles firmly attached in correct orientation. Correct tips on nozzles
	4: Antenna	External RFD Antenna screwed on
	5: Battery	Battery fully charged and undamaged, battery plug connected firmly and completely into drone connector. Battery strapped in tight and loose extra strap tied off secure
STEP 2:	**AGROSOL**	
	1: Connect	Plug in RFD to computer, connect to drone
	2: Pump	Arm Pump; Test pump
	2: Radar	Radar Altimeter shows good reading
	3: Battery	Full battery reading on AgroSol readout: 49.0 – 50.5 V
	4: Mission Settings	A. Safe Spray Altitude B. Safe Minimum RTL Altitude C. Mission Land Point at drone location D. Mission & RTL lines do not cross obstacles E. Upload Mission
	5: Drone Settings	A. Safe Drone RTL Altitude set below mission minimum B. Check following are set as desired: Empty tank RTL, Area RTL, Obstacle Detection, GCS Failsafe, Minimum Flowrate
STEP 3:	**LOCATION**	
	1: Takeoff & Land Area	A. Ground is flat and level B. No people or obstacles near drone
	2: Spray Area	A. No high-tension power lines within 100 ft of spray area (High-Tension lines: 68kv-1mkv, system interference risk) B. No visible unmarked obstacles in spray area
	3: Weather	Follow flight envelope
STEP 4:	**ARM MOTORS & TAKEOFF**	
	1: Arm Motors	A. Arm Motors B. Wait for all 4 motors to spin up C. No errors in AgroSol
	2: Takeoff	A. Click Take Off B. Drone climbs to correct RTL altitude C. Drone flying smooth and stable D. No strange noises from motors
STEP 5:	**LAND**	
	1: Monitor Landing	Monitor drone as it descends to land, be ready to pause drone and adjust landing location if necessary

Calibrations

Note: ONLY the compass calibration is required before first flight. All other calibrations are completed in the factory. Accelerometer, level, and voltage may never be required by the user. Flowmeter calibration may be periodically required to improve accuracy.

Compass

1. Connect to drone. Go to maintenance tab and click “Calibration > Compass”
2. Grab the drone and lift it up. Hold the drone level:
   By taking small steps, spin in place for a total of 360 degrees in the clock-wise direction. You should end up facing the same direction that you started.
3. Repeat step 2 while holding the drone with its right side down, left side down, on its back, nose facing up, and nose facing down.
4. The calibration is complete when both GPS status bars reach 100%. Restart the drone before flight. If the calibration fails, restart the drone and try again.

Accelerometer

1. Connect to drone. Go to maintenance tab and click “Calibration > Accelerometer”.
2. Place the drone on an extremely flat and level surface. Click “Next” on AgroSol.
3. AgroSol will prompt you with “Left”, “Right”, “Nose Up”, “Nose Down”, and “Back”. Hold the drone with the prompted direction facing down to the ground. Hold it very steady and click next until the new direction is prompted by AgroSol. Continue until each orientation has been calibrated.
4. AgroSol will notify you when the calibration is complete. Restart the drone before flight.

Level

1. Connect to drone.
2. Place the drone on an extremely flat and level surface.
3. Go to maintenance tab and click “Calibration > Level”.
4. Restart the drone before flight
5. Do the Level Calibration BEFORE the Accelerometer Calibration

Voltage

1. Locate voltmeter, set to measure voltage to 0-100 volts.
2. Measure voltage of two UAS batteries, add together voltage.
3. Power on drone using these batteries.
4. Connect to drone.
5. Go to maintenance tab and click “Calibration > Voltage”.
6. Type in the measured voltage sum and press OK.
7. Check the AgroSol voltage readout matches the measured voltage sum.
8. Repeat if the voltages do not match.

Flowmeter

1. Connect to drone. Go to maintenance tab and arm the pump.
2. Connect the spray booms normally as for a spray mission.
3. Use a graduated cylinder to measure out a precise volume of water. The greater the volume of water, the more precise this calibration will be. Use at least 0.5 gallons.
4. Make sure the tank is completely empty. Pour the water into the tank. Do not forget the exact volume of water.
5. DO NOT rely on the markings on the side of the tank to indicate volume of liquid. This is not precise enough, use a graduated measuring container.
6. Select “Calibration > Flowmeter”.
7. Type in the amount of water poured into the tank. Press Next.
8. Make sure the drone is in a place where it can spray out all of the fluid in the tank. Press Next.
9. The drone will now spray out all of the tank in the fluid. Wait for it to finish. The pump will stop on its own.
10. AgroSol will notify you when the calibration is complete. Press Next.
11. Repeat if performance does not improve. Make sure to measure accurately.

UAS Spraying Tips

Nozzle Selection

Proper nozzle selection is important to high quality spray performance with the AgroDrone.

Select a nozzle based on your desired particle size, flowrate, and spray profile.

The TeeJet nozzles listed are commonly used by Hylio pilots around the world, and have proven to fit well with the AgroDrone’s nominal pump pressures and flight speeds.

Nozzle Type	Options	Performance	Image
Very Fine Particle Hollow Cone: TX-VK VisiFlo	TX-VK4 TX-VK6 TX-VK8	▪ **Size VF to F** Particle at 0-5 bar ▪ VK4: Most Fine ▪ VK8: Least Fine ▪ 0.22 – 0.73 L/min/nozzle	
Fine Particle Flat Fan: XR TeeJet 80-VS	XR8001-VS XR80015-VS XR8002-VS	▪ **Size F to M** Particle at 0-5 bar ▪ 8001: Most Fine ▪ 8002: Least Fine ▪ 0.23 – 0.91 L/min/nozzle	
Coarse Particle Flat Fan: AIXR TeeJet 110-VP	AIXR110015VP AIXR11002VP	▪ **Size M to XC** Particle at 0-5 bar ▪ 110015: Most Fine ▪ 11002: Least Fine ▪ 0.34 – 1.12 L/min/nozzle	

Drone is shipped with TT11001. This nozzle is recommended for a broad range of applications.

How to choose spray settings

1. Determine required Gal/ac of chemical that is to be applied
2. Dilute solution with water to the strongest acceptable concentration (stronger concentrations are best for low volume applications using drones)
3. Use water dilution ratio and required chemical Gal/ac to calculate Gal/ac required for dilution
4. Test maximum flowrate through pump with this chemical dilution and your selected nozzles. This can be done in the maintenance tab spray controls section.
5. Use the speed calculator application in the AgroSol maintenance tab toolbox to determine your maximum flight speed given the maximum spray flowrate, and spray swath width. Always try to fly at the highest speed safely possible to increase efficiency and keep your pump output to maximum.
6. Create your spray mission with the calculated speed, dynamic flowrate, and swath width

Flight Parameters and Terrain Considerations

Flight Speed	Whenever possible, use the toolbox speed calculator to determine flight speed as described
Cruise Altitude	The cruise altitude is used when ferrying to and from the spray area. Set this altitude higher than any obstacles nearby the field, such as fences trees or vehicles. The drone WILL fly outside the marked spray area when at this altitude for takeoff, RTL, and pause control. This altitude should be set as low as possible to reduce battery drain while remaining above obstacles
Spray Altitude	The spray altitude is used during the spray portion of the mission. This should be selected based on crop height. Start with a high value, and decrease the altitude as you observe the flight response to your selected altitude value. You should spray 10 ft above most crops
Swath Width	This value will almost always be 15 ft when using normal spray settings (1-2 gal/acre). The width will shrink and the pattern will increase in variance as you go over 15 mph.
Spray Angle	Select a spray angle to maximize straight lines in the mission, or to match crop rows. Longer straight lines will improve efficiency
Terrain Considerations	For terrain with many obstacles or variable topography, fly higher and slower. You can decrease altitude and increase speed as you observe the drone's response to terrain variations. Fly along hillsides whenever possible as opposed to up and down hillsides. This is much more efficient and keeps the drone from constantly climbing up and down hills.

First Flight

It is recommended to perform the first flights alongside a Hylio representative until the new owner is an adequately competent pilot. Follow this checklist, followed by the preflight checklist to ensure a safe and smooth first solo flight.

Environment	
1	Bring the drone and all tools to a safe and controlled environment
2	The location should be an open field with NO OBSTACLES anywhere nearby, in case of an unexpected mistake in control
3	No people should be present except the pilot and any person directly involved with assisting the operation
4	Move all vehicles well clear of the operation area
5	Make sure the weather is clear with low winds and will stay that way for the extent of the operation
Initial Setup	
1	Set up a table and chair for the ground station computer
2	Make sure you have power available for the ground station computer in case it runs low on battery. Take out the RC and set it on the table in case of emergency
3	Set the drone up at least 20 yards away from the ground station
4	Make sure the drone is on level ground and the surrounding area is relatively level in case landing is not in exactly the same spot
5	Set up the arms and straighten out the propellers. Make sure the propellers are as straight as possible, this will reduce vibration on takeoff
6	Load the tanks. Do not fill the tanks all the way, start off with just 1 gallon of water in each tank.
7	Place the batteries in the frame and connect them to the drone
Mission	
1	Use the tracker to mark off a small area (around ½ acre) in the field far from any obstacle
2	Draw the mission boundary in AgroSol. Choose all mission settings carefully. Pay particular attention to altitude selections. Make sure the pump is enabled in the mission.
3	Proceed to follow the preflight checklist VERY CAREFULLY through takeoff
4	Fly many missions to gain practice and comfort with the system before you begin using the drone to spray chemicals.

Manual Flight & RC Takeover

It is NOT recommended to fly the UAS manually. However, the drone can be flown manually from takeoff to landing if necessary. In the case of an emergency, the RC can also be used to take over manual control of the drone. Follow these checklists to ensure safety of manual flight.

Fully Manual Flight

1	Memorize the RC instructions on page 7 of this document
2	The drone must be in Position Hold Flight Mode for manual flight
3	To arm the drone, hold the throttle stick in the bottom right corner for 3 seconds. This will have the same effect as pressing “ARM” in AgroSol. The motors will begin to idle. If you do not proceed to takeoff in 10 seconds the drone will disarm itself
4	Once the motors are armed, raise the throttle stick above the center to around 75% of maximum. The drone will throttle up the motor speed to take off and continue climbing until the throttle stick is returned to 50%, where it will maintain altitude
5	There is no pump control on the RC, to spray while flying manually, go to the maintenance tab in AgroSol and use the pump tester to control the pump
6	To land, make sure you are bringing the drone down over a level area. Slowly bring the throttle down below 50% and the drone will descend. Slowly descend until the drone is on the ground. Once the drone is on the ground, bring the throttle down to 0%
7	If you have trouble landing, you can always press “LAND” in AgroSol and the autopilot will take over and autonomously land in the current location
8	To disarm the drone, hold the throttle stick in the bottom left corner for 3 seconds. Until you disarm, the motors will continue to idle as the drone sits on the ground

Manual Takeover During Autonomous Flight

1	To take over during manual flight, power on the RC. The RC will remind you to set your flight sticks and switches to the default positions (default positions on page 7)
2	**FIRST take the throttle stick and put it to the 50% middle position. THIS STEP IS EXTREMELY IMPORTANT.** If you leave the stick down at 0%, the drone will immediately begin descent as soon as you manually take over
3	Take the flight mode switch and flip it down to RTL and back up to Position Hold 2 times. Leave the switch in Position Hold Flight Mode
4	If you have successfully taken over, the drone will immediately stop and wait for your manual commands. If the drone continues, try flipping the flight mode switch again.
5	This switch can be used in case the connection to the ground station has been compromised to command the drone to autonomously LAND or RTL
6	Once you have manually taken over, the mission cannot be resumed. You must proceed land and reupload a mission.
7	At any time during manual control, AgroSol can be used to take back over and command a PAUSE, RTL, or LAND using the telemetry link.

Safety Guidelines

Large Agricultural UAS can be extremely dangerous if used improperly. The following guidelines and limitations must be followed to ensure safe and effective operation of the AG-110.

Flight Envelope

Altitude	0 – 100 ft AGL
Speed	0 – 25 mph
Precipitation	None – Light Rain
Temperature	40 – 100 deg F
Wind	0 – 20 mph
Load	0 – 25 lbs
Battery Voltage	50.4 V: Fully Charged 42.6 V: Initiate Automatic RTL 41.0 V: Initiate Emergency Land 40.0 V: Motor Power Cut

Field Marking

1	All Flags must be placed 6 ft within the active application area. The GPS Tracker drops “Flag” markers in AgroSol to reference when manually drawing application area polygons. These flags must be marked 7 ft within the application area to account for possible GPS inaccuracy.
2	All obstacles must be marked 10 ft larger than actual size. The GPS Tracker drops “Obstacle” markers in AgroSol that force the flight path to avoid that area. AgroSol allows the user to select an obstacle radius. This radius must be set 10 ft larger than the radius of the obstacle.
3	Drop boundary-flags every 100 ft when marking along a straight field edge.
4	Drop boundary-flags every 25 ft when marking along a curved field edge.
5	Always mark ALL obstacles within a field. Do not rely on obstacle avoidance.
6	Always mark field edges when spraying a field with many trees, power lines, or other obstacles near the field edge.

Mission Settings

1	Before drawing a mission boundary, the field must be surveyed to check for obstacles within or around the mission area. Fields with extreme altitude differentials should not be sprayed. Fields with an extreme number of in-field obstacles should not be sprayed.
2	Mission boundaries should NEVER be drawn outside marked boundary-flags. (if the field was marked with GPS Tracker)
3	RTL height must be at least 15 feet above all obstacles near the mission area. Should the UAS automatically RTL at any point in the mission, this RTL altitude must be high enough for the UAS to safely return home and land.
4	Land Points must be set with a 15 ft radius of flat and clear ground. If operating multiple UAS: All land points must be 40 ft apart.
5	Spray Altitude must never be set below 4 ft on an application area with flat and level ground and crops below 2ft tall. Spray Altitude must never be set below 10 ft on an application area with uneven/hilly terrain and crops below 2ft tall. ALWAYS adjust spray altitude with consideration for topography and crop height.
6	ALWAYS select mission speeds and altitudes within the Flight Envelope.
7	Select flight speed based on topography and spray settings. Fly slower in hilly terrain. Fly slower for high flowrates. Use the AgroSol Toolbox Speed Calculator to determine max speed when spraying with viscous fluids or at high rates.

Storage & Transport

1	Always store all UAS, Batteries, and Charging Equipment between 50 – 85 deg F. For long term storage, all hardware should be stored in a climate-controlled environment.
2	A fire extinguisher must always be available nearby batteries in transport or storage.
3	Always strap down UAS during transport to avoid damage.
4	Batteries in long term storage must be at a storage charge voltage level (46.2 V).
5	Spray System must be extremely clean before long term storage to avoid damage.
6	Cycle batteries once every 4 months to ensure longevity (charge/discharge to storage)

UAS Operation

1	Never operate UAS outside the flight envelope.
2	Never fly within 100 ft of high-tension power lines. (High-Tension lines: 68kv-1mkv, system interference risk)
3	If the UAS is in an uncontrolled climb for any reason, press LAND. This will force the UAS to ignore all altitude sensors and begin decent
4	Always follow the preflight checklist.
5	Always verbally announce takeoff and landing.
6	Always follow applicable regulations at the location of operation.
7	Never fly over people, buildings, or vehicles unless absolutely necessary.
8	Always monitor the Ground Control Station for errors or potential problems.
9	Do not stand within 20 ft of the UAS during takeoff or landing.
10	Never fly under the influence of alcohol or drugs.
11	Always be aware of the application area airspace and surrounding environment.
12	CAUTION: A payload of 22lbs (10 liters water) will put the aircraft over the 55lb limit for sUAS (55.3lb). If the tank is filled all the way to the top it may result in over a 10L volume. Various loads whether fluid or solid may have weight differences. Always account for these differences when loading the aircraft in order to stay under the 55lb sUAS limit.

Battery Safety

1	Batteries should be fully charged before each use
2	Be aware that LiPo batteries can be extremely dangerous if not handled properly
3	Always keep rubber battery connector cap over the battery lead at all times unless the battery is in use
4	Be careful not to short battery leads when plugging/unplugging from UAS
5	Always store and transport batteries in fire-proof lipo safe bags. DO NOT GET BALANCE CABLES/PORTS WET OR DAMAGE BALANCE CABLE HOUSINGS.

Chemicals and Environment

1	Always wear appropriate personal protective equipment when handling chemicals.
2	Always read pesticide label before use. The label is the law.
3	Thoroughly clean spray system when switching chemicals. Chemical residue can get caught in the tube connectors and contaminate the following application.
4	Never dump leftover chemicals in or near the application area. Locate a safe deposit for chemical disposal to use.
5	Do not mix chemicals for application without advanced knowledge of pesticide application. Some chemicals may be extremely dangerous when mixed improperly.
6	Always be aware of potential drift from the application area. Make sure all people and animals stay clear of the application area for the label designated time period.

Multi-UAS Control

1	Take Off and Land Points of multiple UAS must be at least 40 ft apart. (AgroSol Enforced)
2	Only take off and land 1 UAS at a time. Stagger take off and landings so Pilot can focus on drones actively taking off or landing.
3	Always be aware which drone is which when in flight or on the ground.
4	Avoid giving UAS “crossing” missions. Each UAS should be the closest UAS to its own mission area. This will help the UAS keep from crossing paths in the air.
5	UAS RTL alts cannot be within 10 feet of each other to avoid collision. (AgroSol Enforced)
6	If using 2 UAS on the same field, start them on similar sides of the field to avoid collision.

Hylio Inc. Support

Initial Training

Owners of the Hylio AG-110 should receive training upon delivery of the UAS. All warrantees are void without proper training. A certified Hylio AgroDrone Systems Trainer will conduct the initial training. Training will take 1 or 2 days, depending on the competency of the prospective pilot. This training is described in detail in “Hylio AG-110 Software and Training Manual>Initial Pilot Training Schedule”. Initial Training will cover and expand upon all information included in the Hylio AG-110 Manual suite.

The UAS owner will be responsible for training and certifying any new pilots to operate their AG-110 at their own discretion. All new pilots should complete the program listed in “Hylio AG-110 Software and Training Manual>Initial Pilot Training Schedule” and follow the recurring training schedule.

Customer Support

Hylio is a US based company, dedicated to providing excellent quality in hardware longevity, software user experience, and customer support/services.

Hylio offers multiple tiers of customer support based on subscription packages. Support ranges from data analytics/cloud services to full-service repairs. Reach out to your Hylio representative for more information on subscription-based warrantees and cloud services.

Hylio representatives are available year-round to provide assistance for any AG-110 owner via telephone 9am – 6pm CST Monday – Saturday.

Appendix

HereLink Remote Controller Upgrade

Overview

Hylio AgroDrones now come with a HereLink TX as the main radio controller. It is used for both manual flight control and FPV video streaming. The HereLink does NOT receive or send telemetry data to Hylio AgroDrones.

Buttons

Press and hold the power button to turn the HereLink on and off. Aside from the power button, there are 4 buttons on the HereLink that are active. All other buttons will have no effect when pressed.

A button: Enter manual flight mode
B button: Enter RTL flight mode (climb to RTL altitude, return to land point, and land)
C button: Enter Land flight mode (land in place)
Right Trigger: Toggle manual spray control

Charging

The HereLink charges through a Micro USB port on the bottom of the device.

Manual Flight

When the drone is on, hold the left stick to the bottom right position to arm the motors. Gently push the left stick (Throttle Stick) up above the middle point to take off. When this stick is above the center, the drone will climb. When the stick is below center, the drone will descend.

Push the throttle stick left and right to yaw the drone left and right.

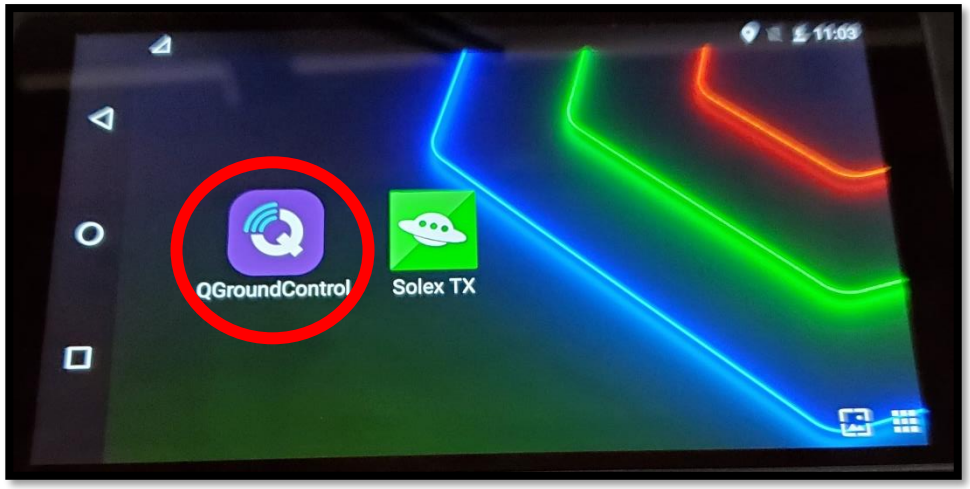
Push the right stick left and right to move the drone left and right. Push the right stick forward and back to move the drone forward and back.

Safety Tips (IMPORTANT)

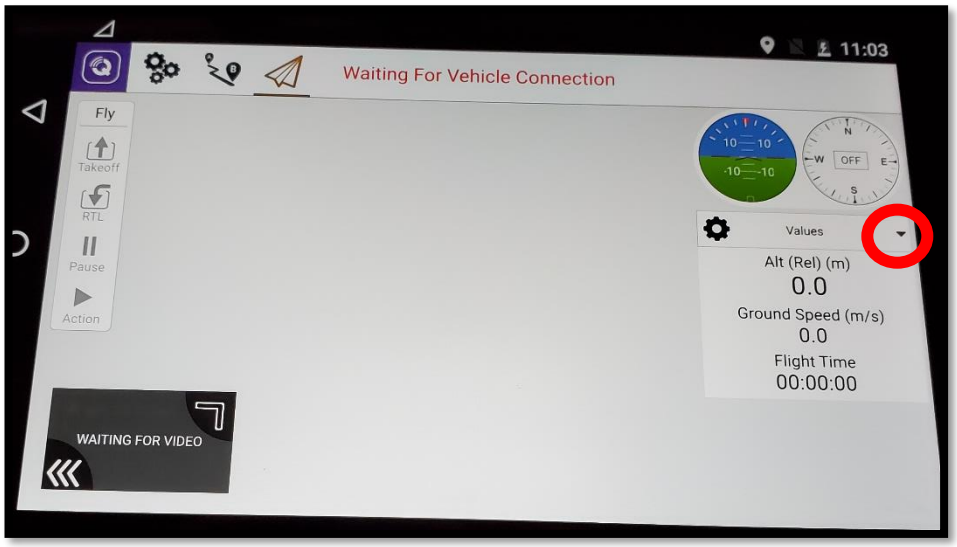
- If you turn on the TX while the drone is in AutoPilot (flying a mission) the TX will take over manual control of the drone. The drone will then stop in place and wait for RC input.
- If the HereLink is turned on, and goes out of range, the drone will enter RTL mode.
- If you lose connection with the herelink, the video stream will cut out. Once you regain connection, the video stream WILL NOT come back until you restart the drone.
- Take off quickly to avoid translational movement near the ground and excessive vibration. Moving left and right near the ground can catch on the landing gear and cause you to crash.
- **Do not edit any settings in the HereLink application menus. This could cause very dangerous unforeseen problems with Manual Flight.** Only use the HereLink touchscreen to navigate to and monitor FPV cameras. Nothing else is enabled.

FPV

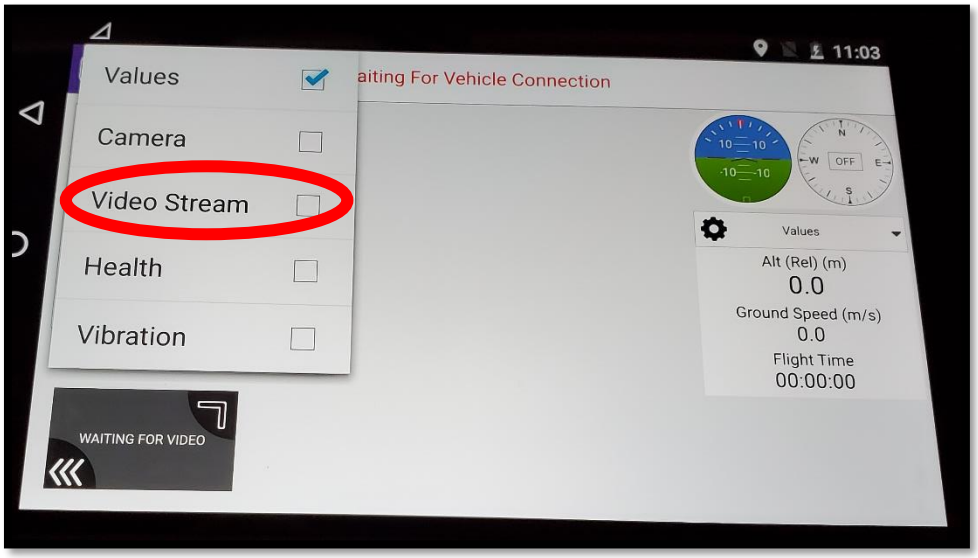
To monitor the FPV camera, first turn on the HereLink. Once it is turned on, select the QGroundControl app.



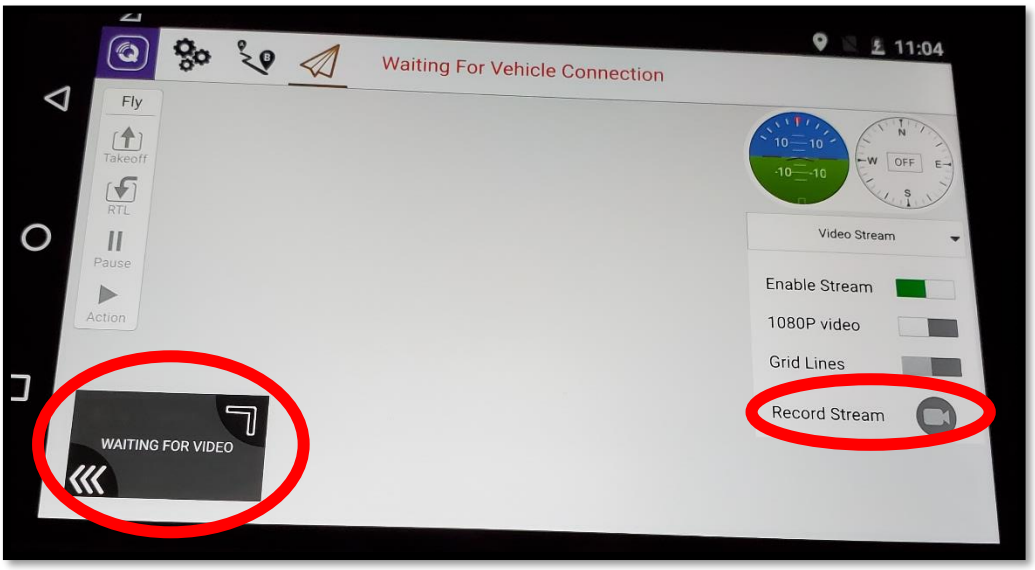
To display the video stream settings, click the small down facing arrow indicated in the picture below.



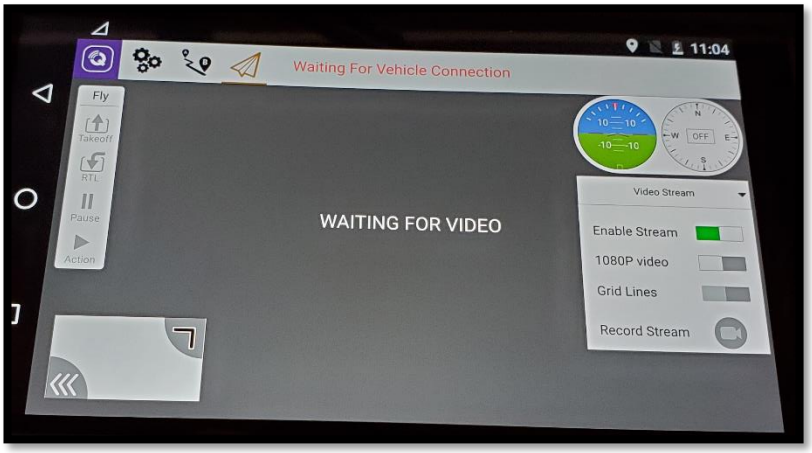
To display the video stream settings, click the “Video Stream” option indicated in the picture below.

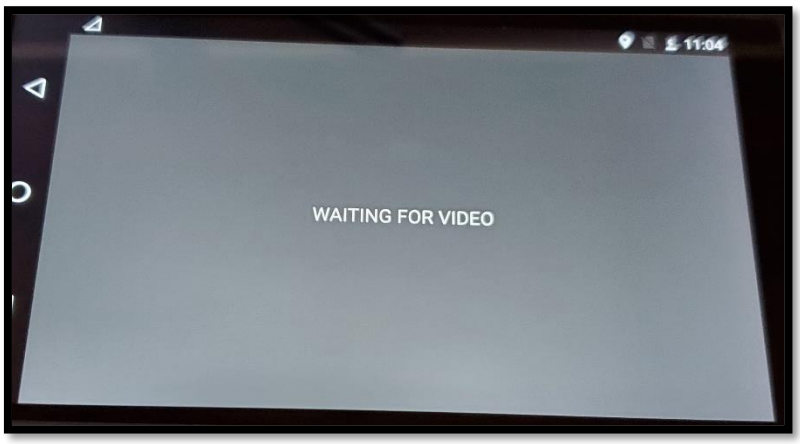


Click the window in the bottom left corner to maximize the FPV. If you select “Record Stream” the video will be recorded on the HereLink, it will not be recorded on the drone side camera. You need to insert a SD card to record video.



Double tap the center of the screen to further maximize the video stream.





Solids Spreader Attachment

Overview

The spreader device is a hardware attachment that enables the drone to spread solids. The device can spread particles between 0.5 – 6 mm in diameter. The spreader motor adds 1.1 lbs. of additional weight when compared to the original liquid tank. The image above shows an AG110 model with the spreader attachment installed.

Connections/Installation

The spreader device comes on a separate tank. This tank mounts in the same way as the fluid tank. To install, remove the 4 M6x25mm fasteners holding the tank in place, remove all tubing and electrical connections (AUX1 cable), and pull out the tank. Secure the Spreader tank in the same place. If you want to remove some weight to make up for the additional weight of the spreader, the pump may be removed as well, but this is not necessary.

The solid spreader will have a cable labeled AUX1 and AUX2. Plug these into their respective labeled cables on the drone side. Test the spreader to make sure everything is plugged in correctly.

Operation

The spreader device operates with almost identical controls to the pump. It can be sped up and slowed down. However, it does not have a flowmeter and must be calibrated with each particulate against output settings similar to a traditional agricultural spreader. Different particulates may have various weights. Be aware of the total weight of product that is put into the tank. Always be sure to stay under the 55lb sUAS limit.

RTK Upgrade

Overview

All Hylio AgroDrones are come standard with RTK compatible GPS. The RTK package comes with an RTK ground station capable of sending RTK GPS corrections to the drone over the telemetry data link, improving GPS accuracy.

What's in the Bag

1) 1 x Tripod
2) 1 x GPS Antenna
3) 1 x RTK Module
4) 1 x Steel Plate
5) 1 x USB-C Cable

How it Works

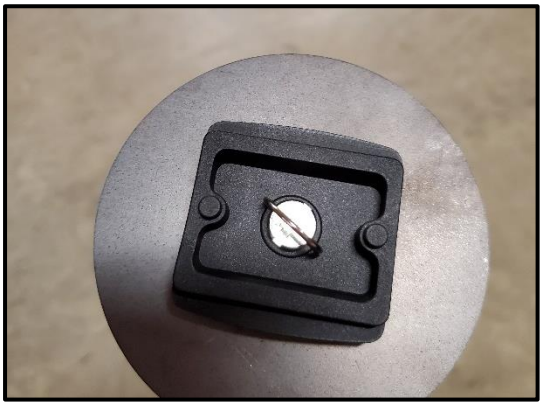
The GPS Antenna connects to the RTK Module, and the RTK Module connects to your ground station laptop with the USB-C cable. Your ground station laptop will need two USB ports: one for the RFD antenna and one for the RTK Module. The RTK Module stays in one place and uses the GPS Antenna to collect GPS signals, and over time it analyzes the drift in these GPS signals. It uses that data to send correction information to the drone, improving it's GPS accuracy in real time.

Hardware Setup

Step 1: Take out the tripod and set it up. The RTK module will come attached to the tripod already.

Step 2: Loosen the black knob on the top of the tripod. Remove the camera mount plate from the top of the tripod.

Step 3: Screw the steel plate on to the camera mount plate from the tripod with the welded nut on the plate facing the camera mount plate. Put the camera mount plate back on to the tripod and tighten the black knob again to secure it in place.



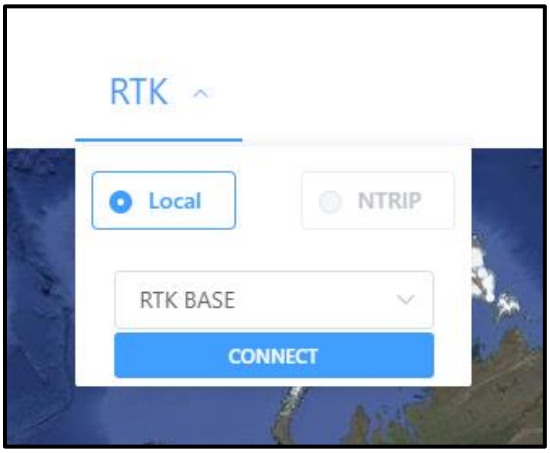
Step 4: Place the GPS Antenna on to the center of the steel plate. Screw the SMA connector from the GPS Antenna on to the connector on the bottom of the RTK Module.

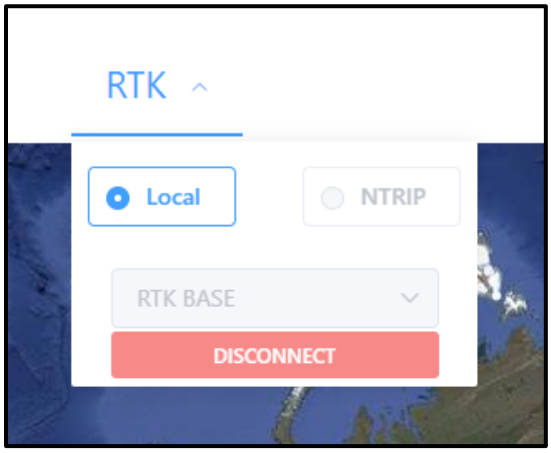
Step 5: Plug the USB-C Cable in to the top of the RTK Module. Place the Tripod in a steady location close to your ground station away from metal objects and make it as tall as possible. Plug the USB-C Cable into your ground station computer. You may need a USB extension cable.

Software Setup

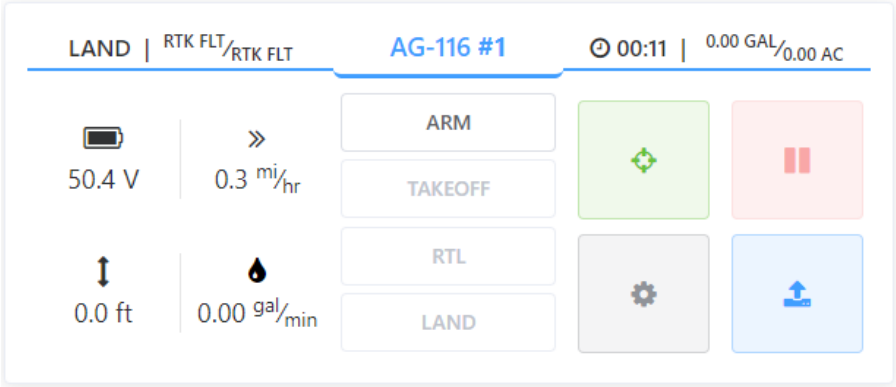
Step 1: Turn on your drone, connect to your drone over RFD. Make sure both your RFD and your RTK unit are connected to the laptop.

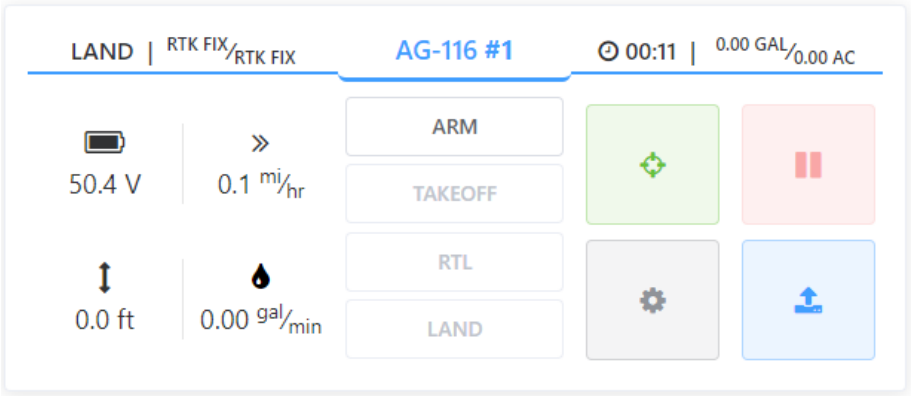
Step 2: Navigate along the top bar in AgroSol and locate the “RTK” drop down menu. Select “Local” option and “RTK BASE” in the dropdown. Click “CONNECT”





Step 3: Your RTK Base Station is now collecting GPS Signals. You must leave the station in one place. The longer you wait, the more the accuracy will improve. Currently we have two indicators of accuracy: RTK Float (RTK FLT) and RTK FIX. These messages will appear in the operations tab in the top left corner of the drone card.





Using RTK

The RTK Base Station should be set up nearby your ground station, where you can have it connected to your ground station laptop. It should also be as high up as possible with a clear view to the sky to get an RTK FIX as quick as possible.

It will take 2-5 minutes after setting up the RTK station before it achieves a status of RTK FLOAT. This should take your overall GPS accuracy from 3m to 50cm.

After another 5-10 minutes you should achieve a status of RTK FIX. This should take your overall GPS accuracy from 50cm to less than 10cm.

However, these accuracies are a reference to the stationary RTK Base Station. These accuracies are not to global GPS. As soon as RTK FLOAT is achieved you have a global accuracy of 2m. This number can be configured to any accuracy you choose, however, wait times to achieve RTK FLOAT increase exponentially as the global accuracy improves. Contact Hylio if you would like to configure your RTK module for higher global accuracy, but with longer wait times.